ABNORMALITIES IN PASSIVE MOVEMENT: DIAGRAMMATIC REPRESENTATION[1]

by

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"Geography would be incomprehensible without maps. They've reduced a tremendous muddle of facts into something you can read at a glance. Now I suspect [passive movement] is fundamentally no more difficult than geography. Except that it's about things in motion. If only somebody would invent a dynamic map."

C. P. SNOW.[2]

A large part of a physiotherapist's work lies in examination and treatment of painful limitation of movement. Though it is desirable that this should always be done with a high degree of precision and skill, it is well known that standards vary. A small percentage of students use their hands naturally, readily acquire manual skill, and improve rapidly with experience. The majority acquire such skill more slowly and take longer to improve with experience. Some students never reach a high standard.

It is important to recognize how complex such skill is. Simple assessment of range and pain gives only a small part of the information needed for good handling. There must be detailed knowledge about the position in range at which pain and physical resistance are encountered, about the relative rate of increase of each, and about the type of resistance present.

The small group of students with innate ability have not only natural dexterity but a very high, natural, detailed perception of these factors. Their performance of manual techniques is continuously modified at an intuitive level by what they see and feel, and consequently their whole approach is more sensitive. This in turn means that they learn far more, far more quickly, than those whose perception is less acute. What is needed is some means by which the majority can be given help in perceiving what the few recognize by instinct.

Teaching this perception in practical terms is exceedingly difficult. Not every patient is suitable demonstration material, and even when a suitable case is available it is not possible, in the best interests of the patient, for all students to handle the joint. In addition, and importantly, one cannot be sure that students have, in fact, felt what they should feel. Nevertheless, there will never be first-class handling and assessment of joint conditions unless the physiotherapist acquires a high degree of sensitivity to signs and symptoms in the abnormal joint. New methods of teaching this aspect of manual skill are needed and they must have, at least in part, a theoretical basis. If these could be developed successfully, students would come to handle joints far more perceptively and would learn far more from each experience that comes their way. The group of students with little natural aptitude would be profoundly helped by being given a theoretical basis for their work, and a means of insight into what is required of them.

During extensive discussions between the authors in 1966, it became clear that some means were needed whereby both could be sure that they were considering exactly the same syndrome at the same time. This meant precise analysis of those very factors referred to above. It was perfectly clear to the

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[2]"Strangers and Brothers", 1965, Penguin Books Limited, England, p. 67.

authors that such analysis was essential for the comparison of the fine differences in treatment and their effect which were under discussion. Gradually a diagrammatic method of communication was developed, which has been named a Movement Diagram.

During the last two years, these diagrams have been introduced to third year students in South Australia. The students are shown what information must be looked for on passive movement and are expected to present their findings in diagram form. These diagrams are checked and corrected so that their important points can be discussed. The students learn far more quickly how to feel and interpret the fine details which can be ascertained by such examination, and it can truthfully be reported that this method has produced a higher standard of interpretation of joint signs and symptoms than has previously been possible. The result is reflected in their more careful handling and assessment of joints.

Movement diagrams depict not only the pain and resistance which are found on joint examination but also the strength of these factors at different points in range. That is, they depict the behaviour of each of the factors throughout the range, and the way in which they behave in relation to each other. The response of the joint to movement is thus shown in a very detailed way. The value of the diagram lies solely in its use as a teaching aid or as a means of communication in technical discussion. The method of arriving at a diagram is described here, firstly by discussing its separate components, and then by showing step-by-step compilation of a total diagram.

The components considered are pain and physical resistance to movement, the latter being sub-divided into the resistance offered by muscle activity such as spasm, and other kinds of resistance free from muscle activity. These are extensive subjects, and it should be clear that the discussion is deliberately limited in various ways. Discussion of pain is confined to pain felt at the site of the joint being examined; referred pain is not dealt with, though if the essence of the exercise is grasped it will be seen how the diagram can be extended to include it. The spasm referred to is protective muscle spasm secondary to joint disorder; spasticity of upper motor neurone disease is excluded. Resistance free of muscle activity is discussed only from the clinical point of view; discussion about pathology is excluded.

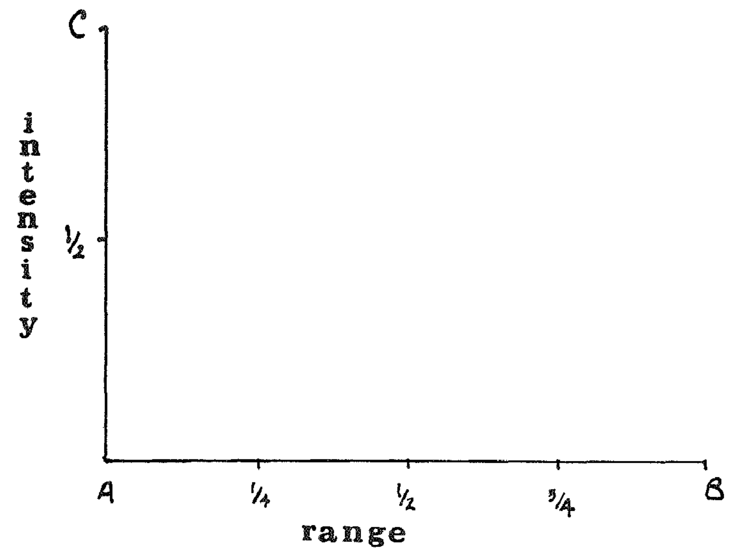


FIGURE 1.

BASIS OF A MOVEMENT DIAGRAM

A movement diagram is compiled by drawing graphs for pain and physical resistance, in which "position in range" is plotted against "intensity" of the factor concerned (Figure 1).

The baseline AB represents any range of movement from the starting position at A to the extreme of normal range at B. It makes no difference whether the movement depicted is small or large, or whether it involves one joint or more than one joint. For example, AB might represent one-eighth of an inch of sterno-clavicular accessory joint movement or one hundred and eighty degrees of gleno-humeral and scapulo-thoracic elevation.

The starting position of the represented movement (point A) is also variable. For example, the position chosen might be the extreme of range opposite to B or a position somewhere in mid-range, whichever is most suitable to the purpose in hand. When it is necessary, in order to make the diagram clear, the position A should be defined. This is done by defining the baseline, for example it might represent one hundred and eighty degrees of elbow extension or ninety degrees of elbow extension.

The point B, representing the extreme of normal range, does not vary in the same way. It must be clearly understood that this point represents the extreme of passive movement and that this lies variably, but very importantly, beyond the extreme of active movement. For example, where the extreme of range depicted involves tissue approximation (as in flexion of the knee), or increasing tissue tension (as in extension of the second metacarpo-phalangeal joint), active range terminates approximately where passive movement encounters the first resistance of the tissues; the end of passive movement lies considerably further into the range, and is accompanied by a build-up of the resistance to movement. By contrast, in extension of the elbow the end of range is defined by a hard "bone-to-bone" feel which is encountered at almost the same point in range both actively and passively. The feel of the resistance offered at the end of range is different in each of the examples given, but in each case the end of active range lies somewhat short of position B.

The vertical axis AC represents the intensity of the factors being plotted; A represents absence of the factor, and C its "maximum intensity". The meaning of "maximum" is discussed in relation to each factor later.

The basic diagram is completed by vertical and horizontal lines drawn from B and C to meet at D (Figure 2).

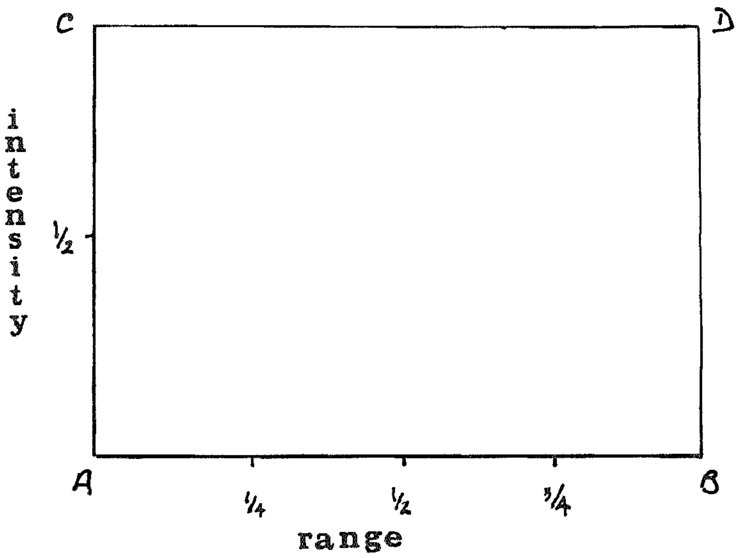


FIGURE 2.

DIAGRAMS OF INDIVIDUAL FACTORS

Examination for pain differs from examination for physical resistance. Although in practice they are assessed at the same time, it is easier to establish their individual characteristics in the first instance if they are considered separately.

Pain

The first fact to be established is whether the patient has any pain while the joint is at rest or not; the joint which is painfree at rest is considered first.

The joint is moved slowly and carefully into the range chosen and the patient is asked to report any discomfort immediately. The position at which this is first felt is not always easy to establish, and several small slow movements may be required to define it. There is no danger of exacerbation if sufficient care is used and the examiner is aware that it is the very first provocation of pain which is being sought. The point at which this occurs is called P_1 and is marked on the baseline of the diagram (Figure 3).

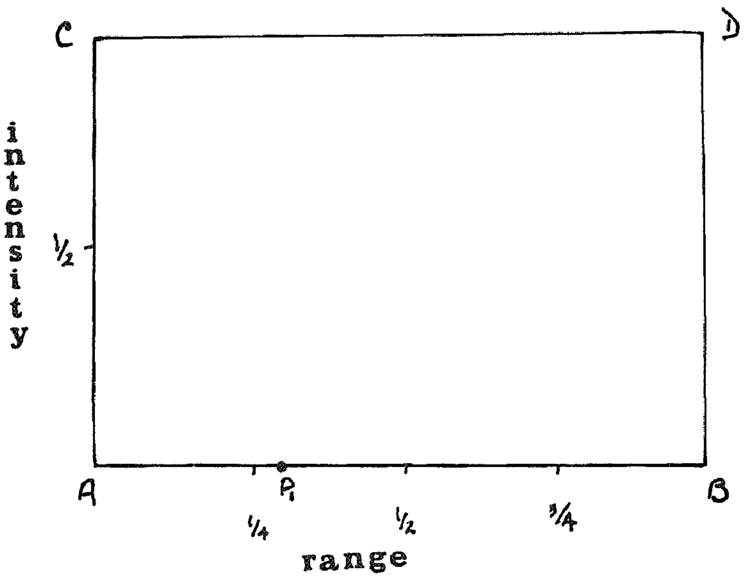


FIGURE 3.

The next step is to show how the intensity of the pain is affected by movement into the painful range. To do this, the intensity of pain in any one position is assessed as lying somewhere between no pain at all and the "maximum" on the vertical axis of the graph (i.e. between A and C). It is extremely important to realise that "maximum intensity" of pain in the diagram *represents the maximum amount of pain which the physiotherapist judges it proper to provoke.* It is thus well within, and quite different from, a level which represents intolerable pain for the patient. Estimation of "maximum" in this way is, of course, entirely subjective, and will vary with the intention in carrying out the movement.

The joint is moved slowly beyond P_1 while the patient is watched carefully to estimate any increase in pain. For example, very shortly beyond P_1 the intensity of pain may increase sharply so that the physiotherapist decides that no further movement should be attempted. This point of limitation in the range is marked on the baseline as L. Since L represents the point at which pain becomes a limiting factor by reaching "maximum intensity", the graph for pain appears as a line drawn from P_1 to intersect the upper horizontal at a position vertically above L. This point is called P_2 (Figure 4).

Pain may not increase evenly in this way; its build-up may be irregular, calling for a graph which is curved or angular. For example, in Figure 5, pain is first felt at about half range and increases more quickly the further movement is taken, reaching a limiting intensity at three-quarter range. In Figure 6 pain is first felt at quarter range and remains at a low level until suddenly increasing to limit movement at three-quarter range.

When the joint is painful at rest students must recognise that it will be easier to exacerbate the symptoms by poor handling. However, if examination is carried out with awareness of the steps described here, no difficulty will be encountered.

It must again be emphasized that this evaluation of pain is purely subjective.

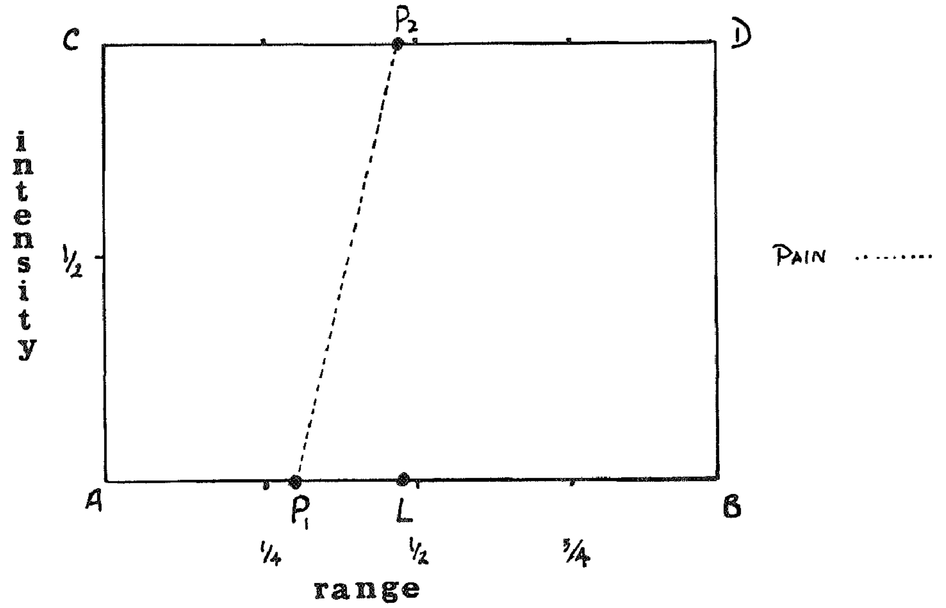


FIGURE 4

Nevertheless, it presents an invaluable method whereby students can learn to perceive the behaviour of pain, and their appreciation of the subject will mature as this type of assessment is repeated from patient to patient and checked against the judgment of a more experienced person.

The examples given above all have pain which limits movement of the joint, but pain may never reach a limiting intensity. For example, in Figure 7 a little pain is felt at half range but hardly increases at all beyond this point; the end of normal range is reached without provoking anything approaching such intensity as would forbid further movement. There is thus no point L and P_2 appears on the vertical line BD at the normal limit of range, where the pain graph intersects it.

Let us now return to the joint which is painful even at rest mentioned at the beginning of this section. An estimate must be made of the amount of pain present at rest, and this appears as X on the vertical axis AC (Figure 8). Movement is then continued carefully until the original level of pain begins to increase (P_1 in Figure 8). The behaviour of pain beyond this point is plotted in the manner already described and an example of such a graph is given in Figure 9.

Physical Resistance

A normal joint, when completely relaxed and moved passively, has the feel of being well-oiled and free running. It can be likened to soap sliding on wet glass. If any resistance is encountered on examination of joint movement an attempt must be made firstly to decide the type of resistance encountered and then to make a graph of its behaviour during movement in the same way as has been described for pain.

Resistance to movement is here divided into two types: the resistance offered by muscle activity such as spasm, and the resistance which has no such component, such as that offered by fibrous tissue contraction. Frequently the difference between them can only be accurately assessed by repeated movement taken somewhat beyond the point at which resistance is first encountered, to feel its characteristics. If pain is severe it may be impossible to carry out this method of assessment, and full examination of physical resistance is then, quite correctly, not completed. In such a case, as always, a balance must be sought between gaining sufficient information to guide treatment, and avoiding exacerbation of the symptoms by over examination.

Provided the quality of pain allows it, repeated movements can be carried beyond the

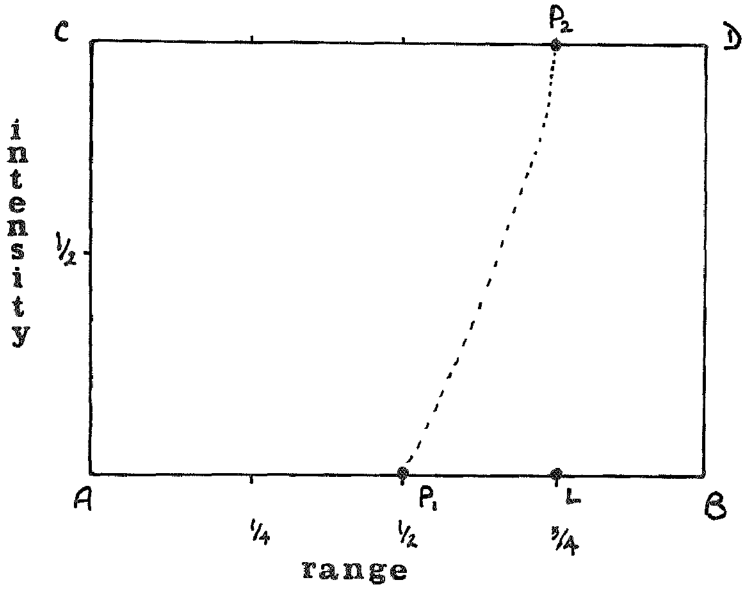


FIGURE 5.

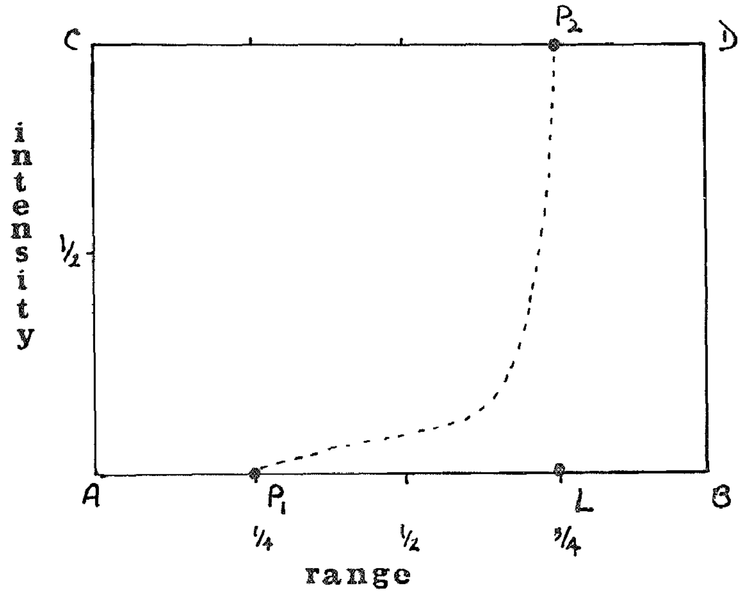


FIGURE 6.

point at which resistance is first encountered. They should be of small amplitude at first, increasing from the very slow to the quick. If this does not give sufficient information, and the state of the joint permits it, the amplitude of the movement can be increased, again beginning slowly and increasing speed with care.

Resistance that is free of muscle activity has the quality of being constant in strength at any given point in the range on repeated movement. In addition, the increase in strength will be in direct proportion to the depth in range, regardless of the speed with which movement is carried out; that is, the

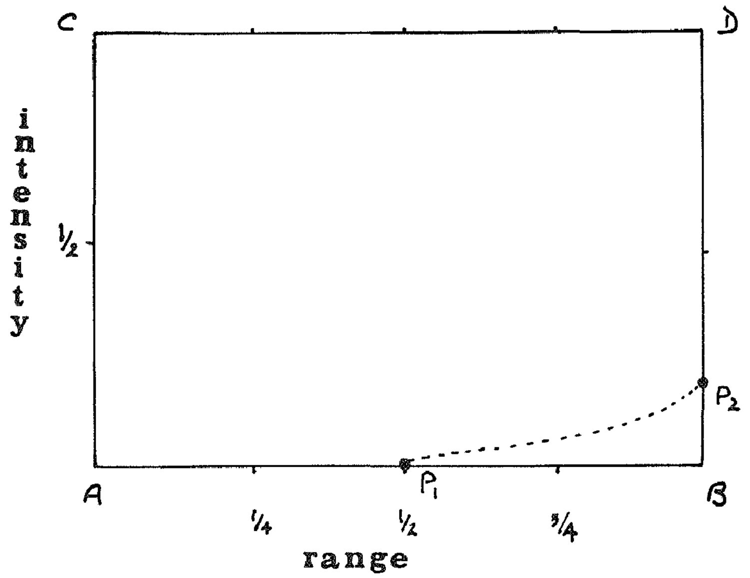


FIGURE 7.

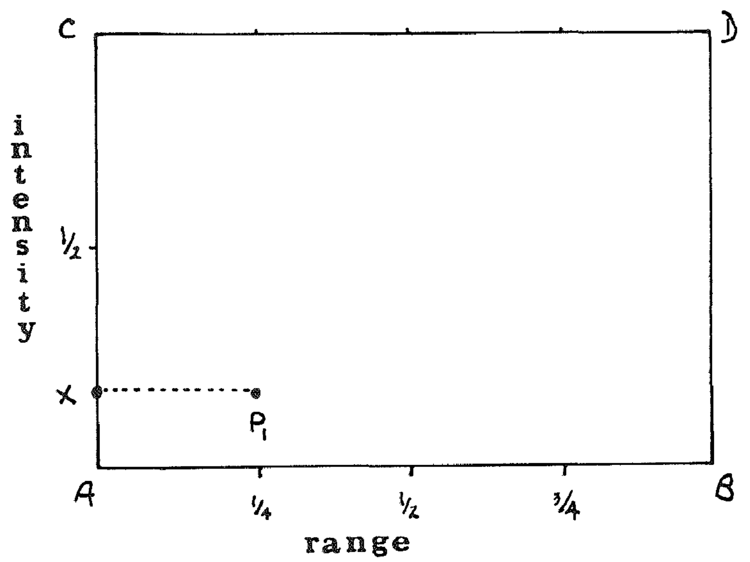


FIGURE 8.

resistance felt at one point in movement will always be less than that felt at a point deeper in the range.

It is characteristic of the resistance offered by muscle spasm that it does not show such consistency. Variations in the method of examination produce variations in the quality of the spasm provoked. In particular, the speed of the examining movement is important, the intensity of spasm at any one position being different if that position is approached quickly or slowly. This is discussed in more detail later in the article. In addition, the resistance of spasm has a marked quality of recoil, whereas this is less noticeable with spasm-free resistance.

Muscle Spasm

As in the case of pain, the intensity of muscle spasm is a subjective evaluation made by the examiner. "Maximum intensity" indicates spasm of a kind which makes the examiner decide to arrest movement, and this is not necessarily of a kind which cannot be overcome. The two may sometimes coincide, but increasing skill and experience will more and more often result in "maximum" spasm being judged to lie well short of intractible resistance. Once again, the student will gain judgment by constantly checking her assessment against that of the experienced physiotherapist.

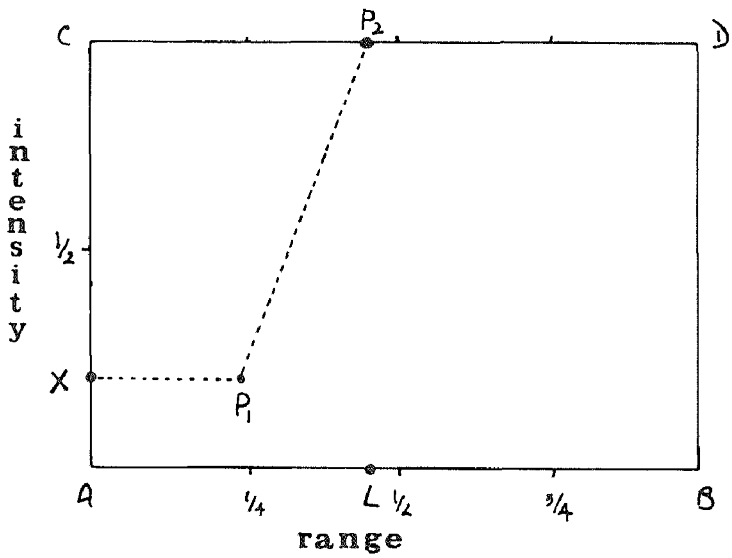


FIGURE 9.

The discussion here is about protective muscle spasm, but reference must briefly be made to the active muscle contraction effected voluntarily by some patients. This voluntary contraction is frequently out of all proportion to the pain being experienced but may be in very direct proportion to an apprehension provoked in the patient about the examiner's intention. Bad, careless, or traumatic handling will provoke such a reaction and obscure the real clinical findings.

Once the type of resistance has been determined, a range/intensity graph can be plotted in the same way as for pain. The method of doing this is now discussed, taking the two main types of resistance in turn.

The joint is moved to the point at which spasm is first elicited, and this point is noted on the baseline as S_1. Further movement is then attempted. If "maximum intensity" is reached before the end of range, spasm thus becomes a limiting factor. This point is noted by L on the baseline and S_2 on the upper horizontal vertically above L. The graph for the behaviour of spasm is plotted between S_1 and S_2 (Figure 10). It will be found that limiting muscle spasm always reaches its maximum quickly, and thus occupies only a small part of the range. It will therefore always be depicted as a near vertical line. Figure 10 shows spasm which has a little "give" before maximum is reached. Figure 11 shows spasm which immediately it is felt is judged to be of a kind to forbid all further movement. In some cases when the joint condition is less severe, a little spasm which increases slightly but never forbids full movement may be felt just before the end of range. In such a case there is no point L and S_2 lies on the vertical line BD (Figure 12).

Spasm-free Resistance

Spasm-free types of resistance are plotted between points called R_1 and R_2 in a way similar to that described for spasm and pain. There are some kinds of spasm-free resistance which cannot be overcome without the use of great force, and "maximum intensity" will here be an objective limitation of movement.

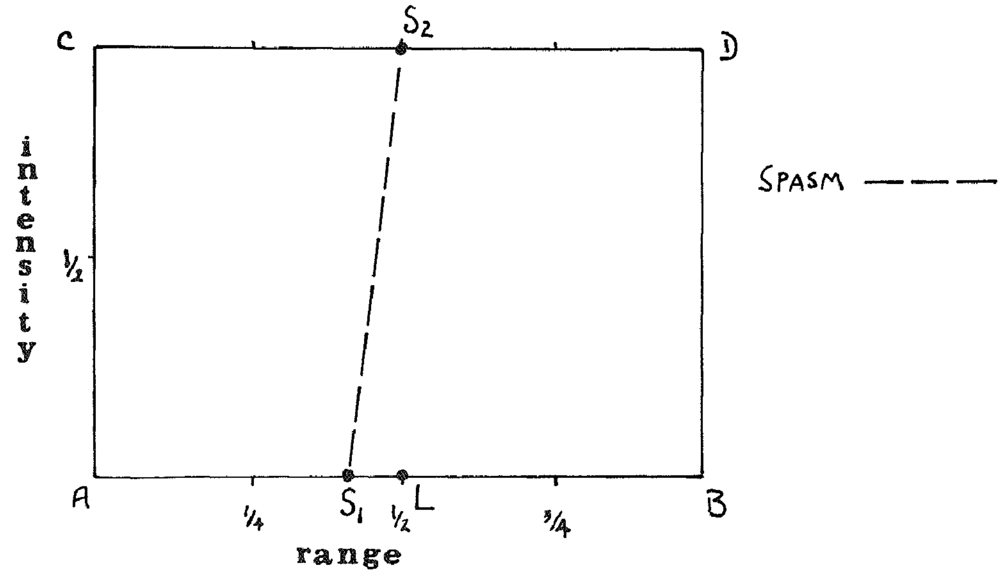


FIGURE 10.

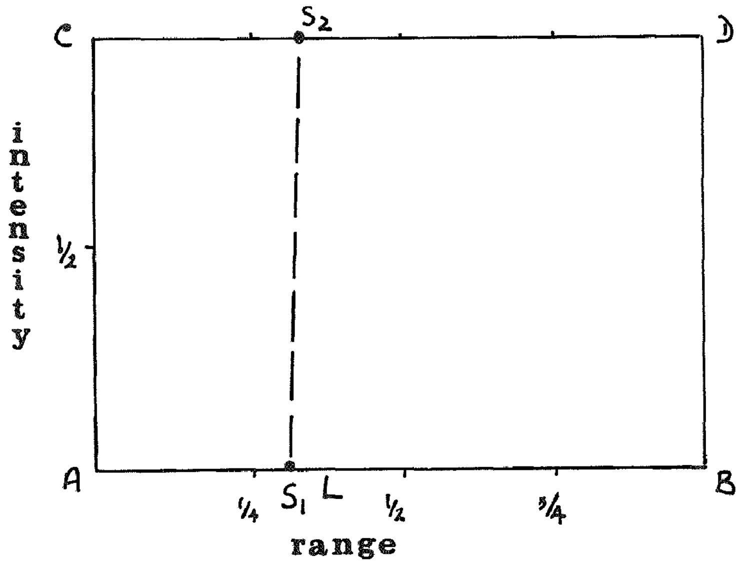


FIGURE 11.

In other cases, the resistance is of a quality which could be overcome if the movement were taken too far, and here "maximum intensity" indicates a subjective limit imposed by the examiner.

The graphs for spasm-free resistance offer more variation than those for spasm, though not as much as those for pain. There is a hard bone-to-bone feel in which resistance suddenly limits all movement beyond the point at which it is encountered and thus appears as a near vertical line (Figure 13). The resistance may have a softer feel, thus occupying a greater span in the range. In this case it may increase slowly at first and then more quickly, appearing as a curved line (Figure 14) or it may increase evenly throughout, appearing as a sloping line (Figure 15). If the resistance is never of such an intensity as to prevent full range, there will be no point L and its graph will intersect the vertical BC (Figure 16).

The first practical step is to examine the movement carefully and to judge at which point pain begins and at which point movement should be stopped. This information is then recorded on the baseline of the diagram as already described. In the example, pain is first felt at about quarter range (P_1) and it is decided not to take the movement beyond three-quarter range (L). (Figure 17.)

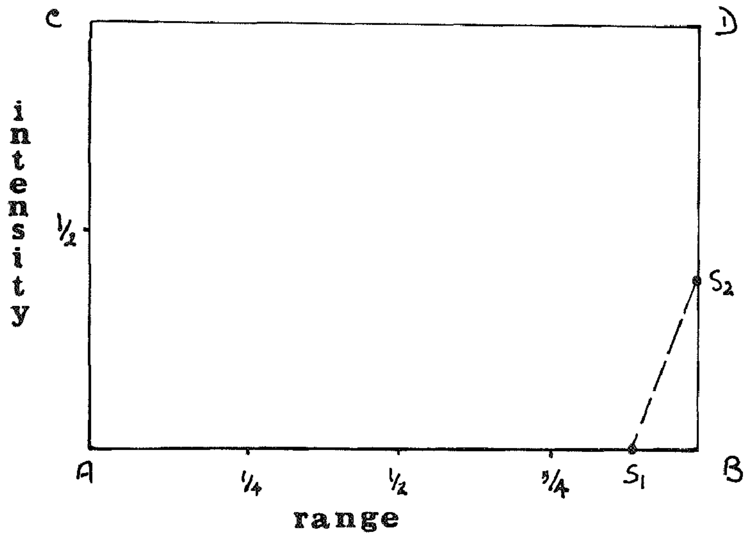


FIGURE 12.

The next step is for the examiner to decide exactly why movement was arrested at L; that is, which factor or factors were judged to be of sufficient intensity at this point in the range for a limit to be placed on further movement. The diagram is marked accordingly on the upper horizontal vertically above L by P_2, R_2 or S_2 to indicate that it was pain, spasm-free resistance or spasm. In the example, it is spasm-free resistance which makes the examiner decide to stop movement, and so only R_2 appears vertically above L (Figure 18).

The point in the range where this limiting factor is first encountered and its behaviour throughout movement from this point are then assessed and its graph completed. In the example resistance is first felt just beyond half range (R_1) and rises steeply to "maximum intensity" at point L (Figure 19).

COMPILING A MOVEMENT DIAGRAM

The routine by which these separate factors are determined and combined in a movement diagram is now described. It will be supposed that a joint which is painless at rest is being examined, and that both pain and physical resistance are encountered on movement.

Since the nature and position of the limiting factor have been completed, any remaining factors must have graphs which terminate on a line drawn vertically above L. The severity of each factor at this point in range, the position at which it was first encountered, and its behaviour between these two points must now be estimated and recorded. In the example, pain is the next factor to be estimated. The onset of pain has already been recorded (P_1) and P_2 is marked above L to indicate its intensity at the limit of range (Figure 20).

The behaviour of pain between these two points is now completed; pain remains at a low level until later in the range, when it increases rapidly as the intensity of the resistance also increases (Figure 21).

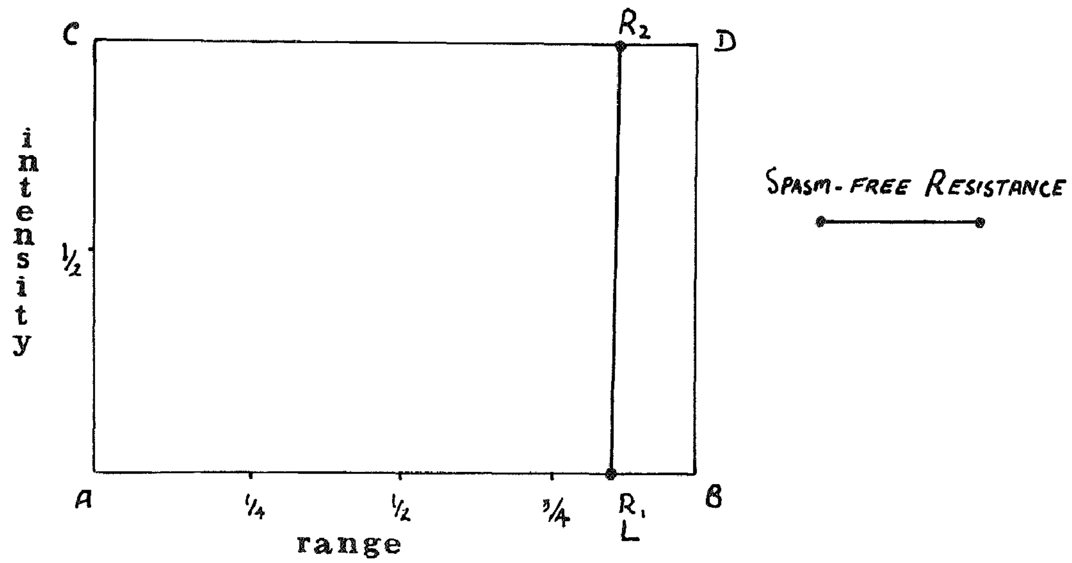


FIGURE 13.

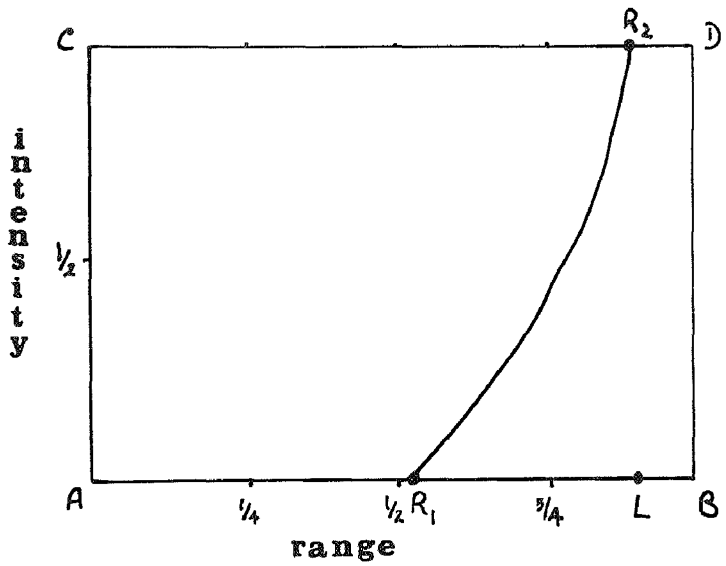
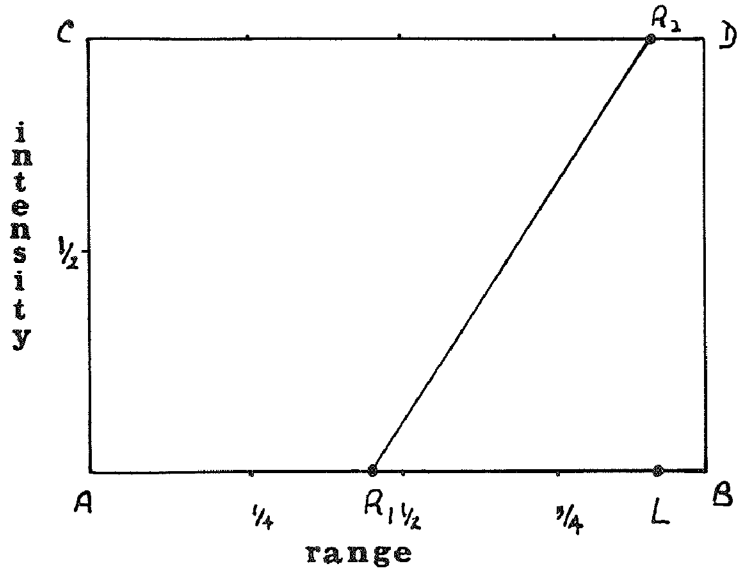


FIGURE 14.

The last factor to be recorded in the example is a small degree of protective muscle spasm felt in the last few degrees of movement, when the intensity of the spasm-free resistance and of pain had both reached a high level. When this is recorded between S_1 and S_2, indicating its behaviour between these points, the movement diagram is complete (Figure 22).

It is best, when examining any joint movement, to record the individual factors in descending order of severity. In the example,



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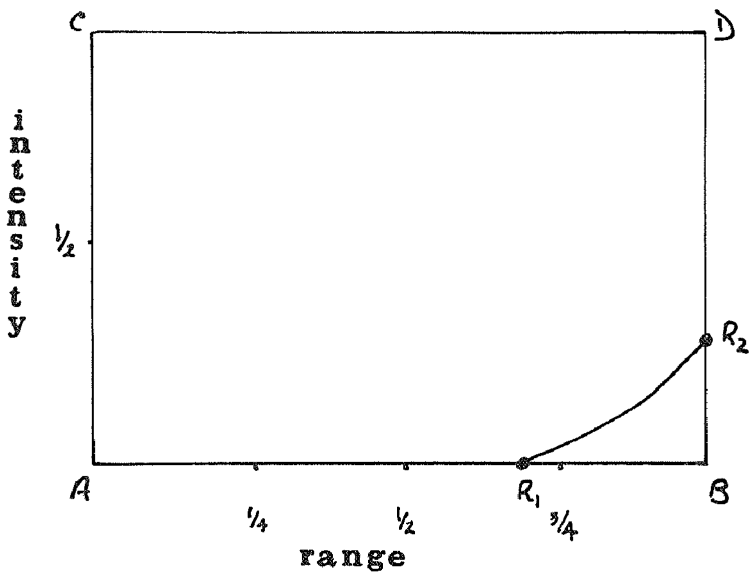

FIGURE 16.

spasm-free resistance was recorded first since this was the limiting factor; pain was recorded next and spasm recorded last. However pain would have been recorded first if it had been the factor which limited movement; similarly, spasm would be recorded first if it were the limiting factor.

DISCUSSION

A student and an experienced physiotherapist, when they examine a joint, may well produce quite different diagrams. It will be useful to demonstrate such differences here, since it will help to show why the subjectivity of the diagram, far from being a drawback,

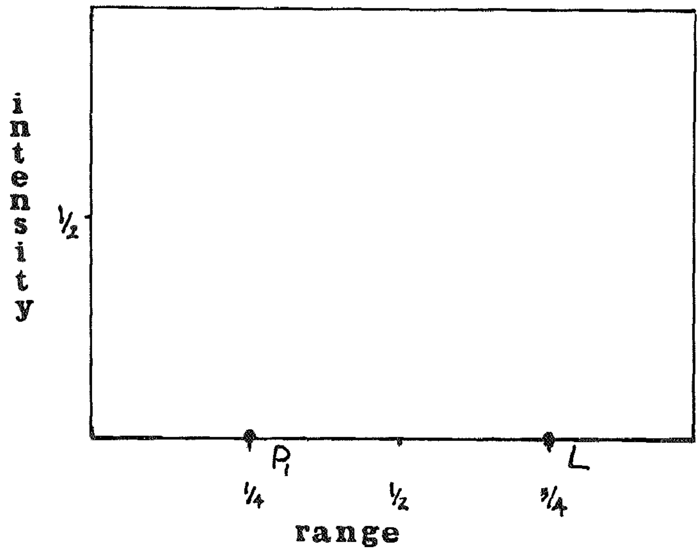

FIGURE 17.

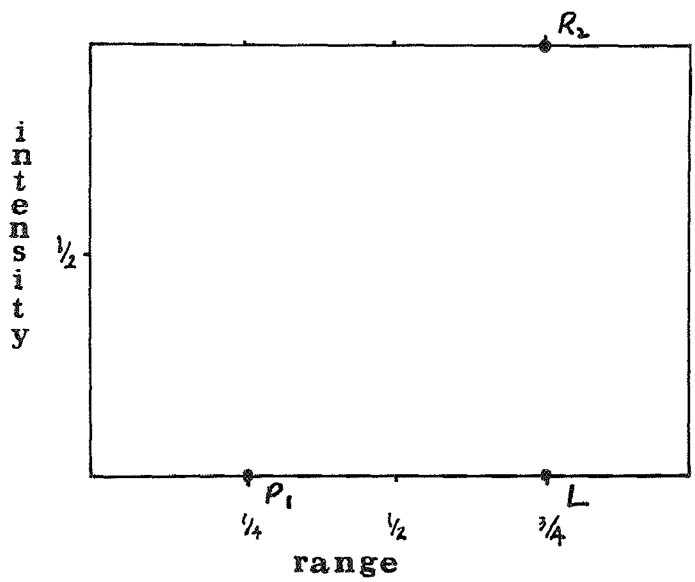

FIGURE 18.

is an intrinsic value. It will also be useful in showing alternative combinations of the different components.

Assuming that Figure 22 shows the movement diagram drawn by an experienced physiotherapist to depict a particular joint condition, let us consider the variations which might be produced by two students after examining the same joint. These diagrams will reflect different characteristics in the students and show what they discover from the joint.

The first student is over-apprehensive about provoking pain (this is far more common among students than the reverse error). She is over-concerned about the increase in pain as she performs the movement, and because of this she arrests the movement a little way

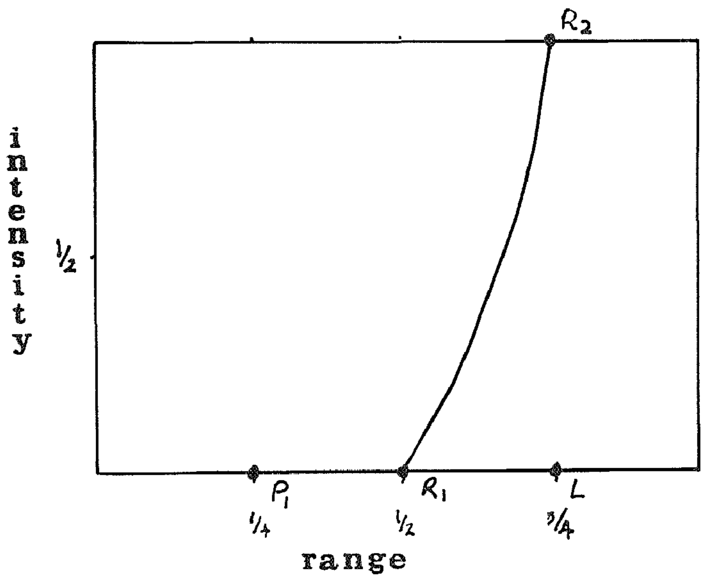

FIGURE 19.

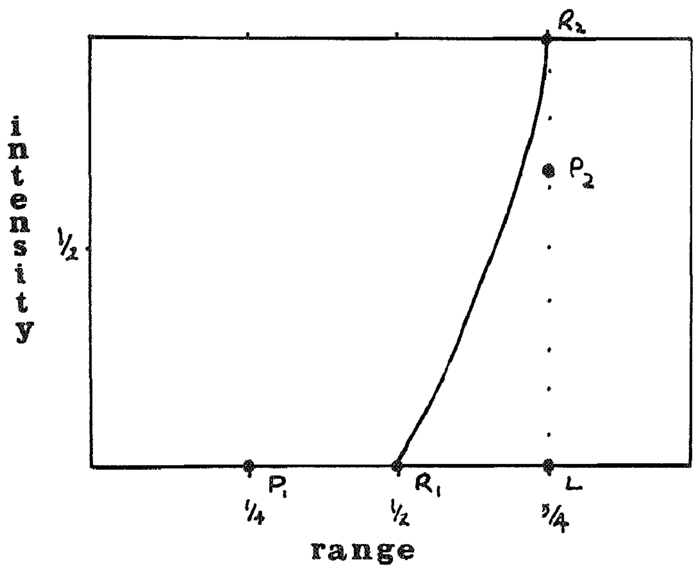

FIGURE 20.

before three-quarter range. This affects her movement diagram (Figure 23) in several ways. Point L occurs a little earlier in the range than in Figure 22 and the limiting factor is pain (P_2 on the upper horizontal), not spasm-free resistance, and the graph for pain rises more steeply than in Figure 22. If her evaluation of the other factors is accurate, the graph for spasm-free resistance will maintain the same slope but will not reach the same intensity because movement is arrested earlier in the range by pain. The graph for spasm is affected in the same way.

The second student under-estimates pain. In her movement diagram (Figure 24) she is accurate in drawing a spasm-free resistance as the limiting factor but she under-estimates the amount of pain felt by the patient at

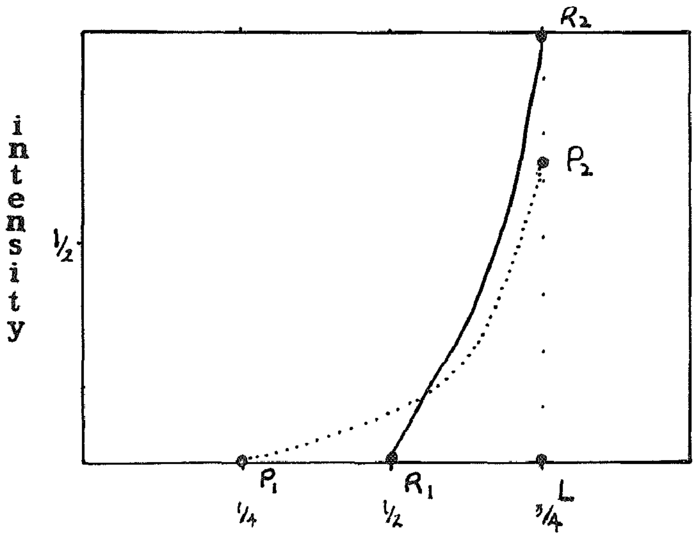

FIGURE 21.

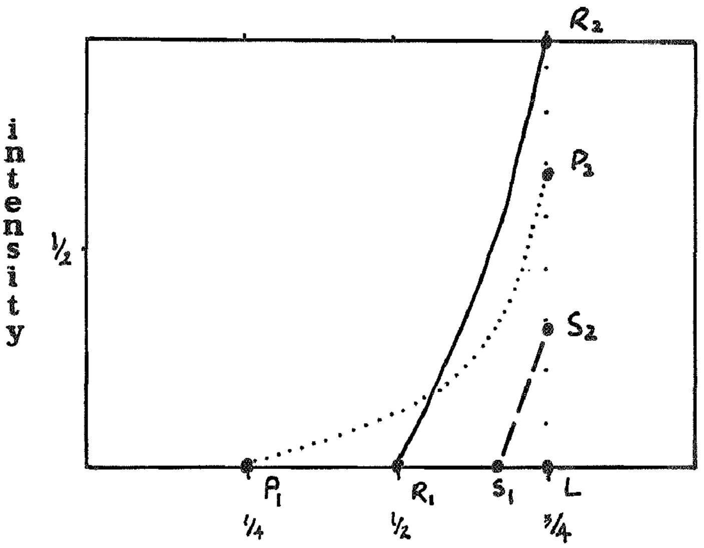

FIGURE 22.

point L. Because she is less sensitive to the behaviour of pain generally, she misses the variation in its rate of increase during movement, and draws its graph as a straight line from P_1 to P_2.

Variations in student estimation and experienced estimation of a situation are to be expected and simply reflect what is true in practise. The analysis of the differences which emerge is in itself the main teaching function of a movement diagram. Differences will also be found between experienced people, reflecting their varying approach to the use of passive movement in examination and treatment. Here again the diagrams can form a means of communication, whereby opinion and knowledge can be exchanged.

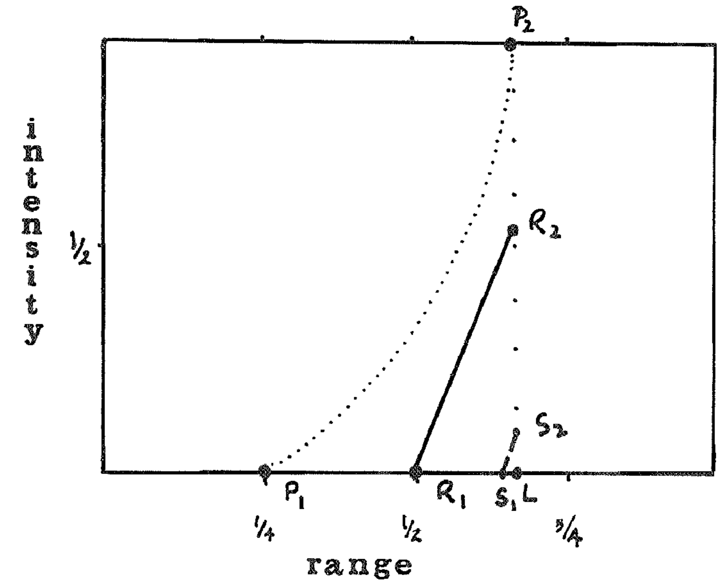

FIGURE 23.

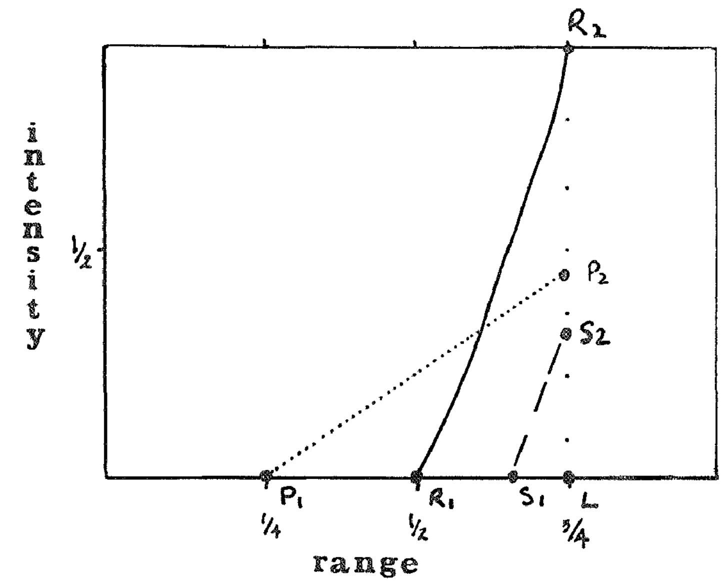

FIGURE 24.

It should also be realised that a condition may itself show differences on examination at different times. For example, while a joint may be pain-free at rest when examined for the first time, a degree of pain may be provoked by examination which remains even when the joint is at rest and which takes some time to subside. If this joint were to be examined for a second time during this period, the pain graph for the second examination would naturally and properly be different from that drawn for the first time.

Intense limiting spasm is also provoked at half range, and thus two factors (P_2 and S_2) appear together on the upper horizontal directly above L. Spasm-free resistance might lie further into the range, but no attempt is made to establish whether this is so or not, because of the position and quality of the pain and spasm already provoked. Thus two factors only appear on the diagram.

The movement diagram indicates the firmness or gentleness with which a joint should be handled. The combination of pain and spasm shown in Figure 25 is suggestive of a condition which requires great respect both in examination and in treatment. Figure 26 shows another combination of two factors, indicating a much less severe condition. A slowly, increasing spasm-free resistance is first felt just before three-quarter range and limits movement just short of full range. Pain is first felt just before the resistance and increases slightly as the resistance increases, but never reaches a high level of intensity. This combination suggests a condition which requires firmer handling, both in examination and treatment.

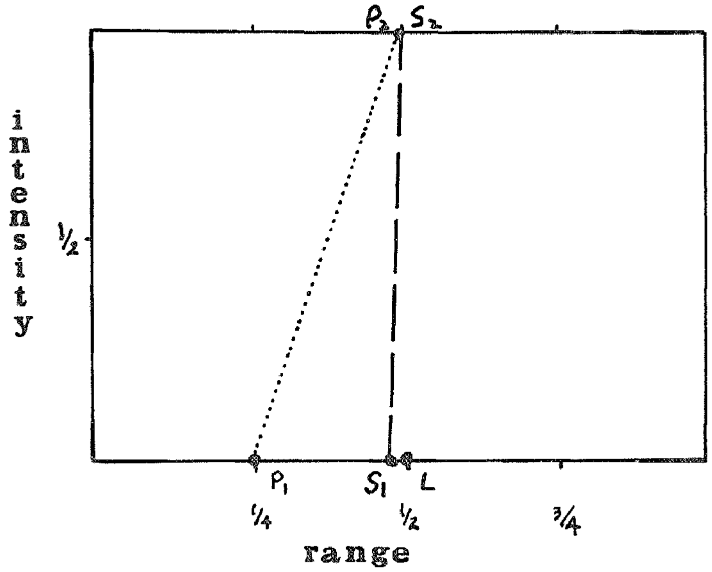

FIGURE 25.

A movement diagram may not initially show all the factors which may be present in a particular condition. For example, if the condition were such that the joint was painful even at rest, the examiner might deliberately curb examination. The movement diagram for such a situation might be similar to that shown in Figure 9 in which pain alone is plotted. The presence of other factors then remains conjectural (though they may be very accurately guessed) since movement was not taken far enough to elicit them.

A more common situation in which all factors may not initially be shown on a movement diagram is when pain and spasm alone appear. For example, in Figure 25 pain is first provoked at quarter range and rises sharply to a limiting intensity at half range.

The diagram reflects the response of the joint to movement, and this response is governed not only by the state of the joint but also by the quality of the examining movement itself. Because the diagrams show the intensity of factors plotted against their position in range, the response of the joint to different depths of movement can be clearly shown. The speed of movement, on the other hand, is not depicted, and something further should be said on this subject.

progress. Therefore, whereas in the early stages of treatment it would be important to minimise spasm, it may later be useful to provoke it by carefully controlled movements, in order to assess its response.

A slow movement of small amplitude, therefore, which is correct examination for

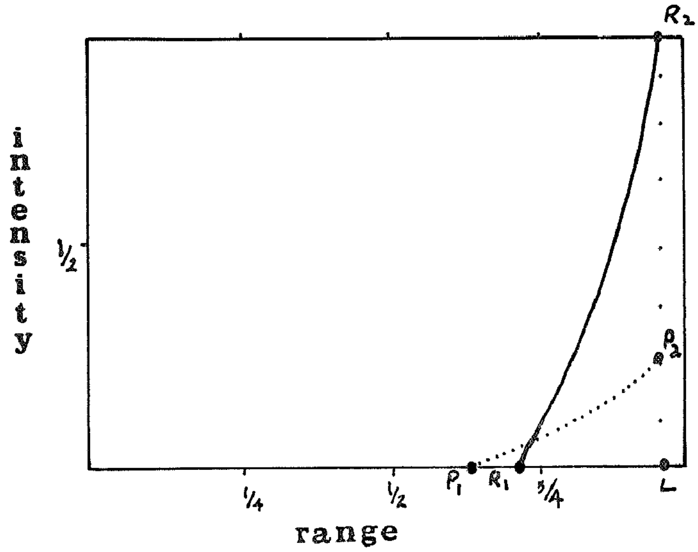

FIGURE 26.

Increased speed of movement may have the effect of provoking pain and spasm earlier in the range and may also increase their intensity. In addition, speed may affect the extent of the spasm. For example, spasm may be provoked in the deep muscles around a joint at a certain position in range which has a consistent minimum response in that it cannot be lessened no matter how the examining movement is modified. It may, however, be very easy to increase this spasm if movement is performed more quickly, especially if the handling is bad and the movement is jerky and awkward. This increase may be shown not only by the spasm being provoked earlier in the range but also by its extending to other more superficial muscles. As the condition improves, the liability of spasm to react to quick movements in this way will diminish, and this in itself is a measure of

one joint may amount to under-examination of a second; conversely, quicker examining movements which are perfectly judged for the second joint may amount to gross over-examination of the first. What is needed is to match the type of movement used in examination to the condition of the joint. A similar matching of movement to joint condition is required in treatment.

The complexity and subjectivity of the aspects of examination discussed here make them extremely difficult to learn, but unless they are learned the handling of joints does not reach a high standard. Movement diagrams provide a method of gaining insight into the way these factors both control and are controlled by the skilled use of movement, both in examination and treatment. They are, to joint movement, what maps are to surface contours.

Summary

The article puts forward a diagrammatic method of depicting signs and symptoms elicited on passive movement of a joint. The reasons for its use and the method whereby such a diagram can be compiled are discussed in detail. A hint is given of the relationship between these joint characteristics and the selection and control of treatment.